

What is claimed is:

1. An apparatus for optically inspecting a sample, the apparatus comprising:
an illumination source that generates a probe beam;
5 a series of optical components that cause a portion of the probe beam to be reflected by a measurement area on the sample surface and subsequently transported to a detector, where the series of optical components includes at least one mirror, meeting the condition $TSE(D) \leq 2e^{-0.15D}$ where $TSE(D) = E_{mirror}(D)/E_{ideal}(D)$ where $E_{mirror}(D)$ is the encircled energy of the mirror measured as a function of the
10 included diameter D and $E_{ideal}(D)$ is the encircled energy for an ideal diffraction-limited mirror of equal focal length and numerical aperture; and
a processor for analyzing signals generated by the detector.
2. An apparatus as recited in claim 1, wherein $TSE(D)$ is a monotonically
15 decreasing function of D .
3. An apparatus as recited in claim 1, wherein the mirror comprises:
a glass substrate; and
a reflective coating.
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4. An apparatus as recited in claim 1, wherein the mirror is formed using a glass
master.
5. An apparatus as recited in claim 1, wherein the mirror is formed by:
25 diamond turning a substrate to a desired shape; and
polishing the substrate to a surface roughness of approximately 10 Angstroms
RMS.

6. An apparatus as recited in claim 1, wherein the mirror is formed by:
forming an aluminum substrate to a desired shape; and
super-polishing the substrate to meet the condition $TSE(D) \leq 2e^{-0.15D}$.
- 5 7. An apparatus for optically inspecting a sample, the apparatus comprising:
an illumination source that generates a probe beam;
a first series of optical components that direct the probe beam to be reflected
by the sample;
a second series of optical components that gather the reflected probe beam
10 from a measurement area on the sample surface, where the series of optical
components includes at least one mirror, and where the series of optical components
transports at least 99% of the gathered illumination to a detector; and
a processor for analyzing signals generated by the detector.
- 15 8. An apparatus as recited in claim 7, wherein the mirror comprises:
a glass substrate; and
a reflective coating.
9. An apparatus as recited in claim 7, wherein the mirror is formed using a glass
20 master.
10. An apparatus as recited in claim 7, wherein the mirror is formed by:
diamond turning a substrate to a desired shape; and
polishing the substrate to meet the condition $TSE(D) \leq 2e^{-0.15D}$ where
25 $TSE(D) = E_{mirror}(D)/E_{ideal}(D)$ where $E_{mirror}(D)$ is the encircled energy of the
mirror measured as a function of the included diameter D and $E_{ideal}(D)$ is the
encircled energy for an ideal diffraction-limited mirror of equal focal length and
numerical aperture.

11. An apparatus as recited in claim 10, wherein $TSE(D)$ is a monotonically decreasing function of D .

12. An apparatus as recited in claim 7 wherein the mirror is formed by:
5 forming an aluminum substrate to a desired shape; and
super-polishing the substrate to meet the condition $TSE(D) \leq 2e^{-0.15D}$ where
 $TSE(D) = E_{mirror}(D)/E_{ideal}(D)$ where $E_{mirror}(D)$ is the encircled energy of the
mirror measured as a function of the included diameter D and $E_{ideal}(D)$ is the
10 encircled energy for an ideal diffraction-limited mirror of equal focal length and
numerical aperture.

13. An apparatus as recited in claim 12, wherein $TSE(D)$ is a monotonically decreasing function of D .

14. An apparatus as recited in claim 7 in which the measurement area is no larger
15 than 50 microns.

15. An apparatus for optically inspecting a sample, the apparatus comprising:
an illumination source that generates a probe beam;
20 a series of optical components that cause a portion of the probe beam to be
reflected by a measurement area on the sample surface and subsequently transported
to a detector, where the series of optical components includes at least one mirror, and
where at least 99% of the portion of the probe beam that is reflected by the
measurement area reaches the detector; and
25 a processor for analyzing signals generated by the detector.

16. An apparatus as recited in claim 15, wherein the mirror comprises:
a glass substrate; and
a reflective coating.
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17. An apparatus as recited in claim 15, wherein the mirror is formed using a glass master.

5 18. An apparatus as recited in claim 15, wherein the mirror is formed by:
diamond turning a substrate to a desired shape; and
polishing the substrate to meet the condition $TSE(D) \leq 2e^{-0.15D}$ where
 $TSE(D) = E_{mirror}(D)/E_{ideal}(D)$ where $E_{mirror}(D)$ is the encircled energy of the
mirror measured as a function of the included diameter D and $E_{ideal}(D)$ is the
10 encircled energy for an ideal diffraction-limited mirror of equal focal length and
numerical aperture.

19. An apparatus as recited in claim 18, wherein $TSE(D)$ is a monotonically decreasing function of D .

15 20. An apparatus as recited in claim 15, wherein the mirror is formed by:
forming an aluminum substrate to a desired shape; and
super-polishing the substrate to meet the condition $TSE(D) \leq 2e^{-0.15D}$ where
 $TSE(D) = E_{mirror}(D)/E_{ideal}(D)$ where $E_{mirror}(D)$ is the encircled energy of the mirror
measured as a function of the included diameter D and $E_{ideal}(D)$ is the encircled
20 energy for an ideal diffraction-limited mirror of equal focal length and numerical
aperture.

21. An apparatus as recited in claim 20, wherein $TSE(D)$ is a monotonically decreasing function of D .

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22. An apparatus as recited in claim 15 in which the measurement area is no larger than 50 microns.

23. A method for optically inspecting a sample, the method comprising:
 generating an optical probe beam;
 using a series of optical components to cause a portion of the probe beam to
 be reflected by a measurement area on the sample surface and subsequently
 transported to a detector, where the series of optical components includes at least one
 mirror, meeting the condition $TSE(D) \leq 2e^{-0.15D}$ where
 $TSE(D) = E_{mirror}(D)/E_{ideal}(D)$ where $E_{mirror}(D)$ is the encircled energy of the
 mirror measured as a function of the included diameter D and $E_{ideal}(D)$ is the
 encircled energy for an ideal diffraction-limited mirror of equal focal length and
 numerical aperture; and
 analyzing signals generated by the detector.

24. An apparatus as recited in claim 23, wherein $TSE(D)$ is a monotonically
 decreasing function of D .

25. A method as recited in claim 23, wherein the mirror comprises:
 a glass substrate; and
 a reflective coating.

26. A method as recited in claim 23, wherein the mirror is formed using a glass
 master.

27. A method as recited in claim 23, wherein the mirror is formed by:
 diamond turning a substrate to a desired shape; and
 polishing the substrate to meet the condition $TSE(D) \leq 2e^{-0.15D}$.

28. A method as recited in claim 23, wherein the mirror is formed by:
 forming an aluminum substrate to a desired shape; and
 super-polishing the substrate to meet the condition $TSE(D) \leq 2e^{-0.15D}$.

29. A method for optically inspecting a sample, the method comprising:
generating an optical probe beam;
using a first series of optical components to direct the probe beam to be
reflected by the sample;
using a second series of optical components to gather the reflected probe beam
from a measurement area on the sample surface, where the series of optical
components includes at least one mirror, and where the series of optical components
transports at least 99% of the gathered illumination to a detector; and
analyzing signals generated by the detector.

30. A method as recited in claim 29, wherein the mirror comprises:
a glass substrate; and
a reflective coating.

31. A method as recited in claim 29, wherein the mirror is formed using a glass
master.

32. A method as recited in claim 29, wherein the mirror is formed by:
diamond turning a substrate to a desired shape; and
polishing the substrate to a surface roughness meeting conditions meet the
condition $TSE(D) \leq 2e^{-0.15D}$ where $TSE(D) = E_{mirror}(D)/E_{ideal}(D)$ where
 $E_{mirror}(D)$ is the encircled energy of the mirror measured as a function of the included
diameter D and $E_{ideal}(D)$ is the encircled energy for an ideal diffraction-limited
mirror of equal focal length and numerical aperture.

33. An apparatus as recited in claim 32, wherein $TSE(D)$ is a monotonically
decreasing function of D .

34. A method as recited in claim 23, wherein the mirror is formed by:
forming an aluminum substrate to a desired shape; and
super-polishing the substrate to meet the condition $TSE(D) \leq 2e^{-0.15D}$ where
 $TSE(D) = E_{mirror}(D)/E_{ideal}(D)$ where $E_{mirror}(D)$ is the encircled energy of the
5 mirror measured as a function of the included diameter D and $E_{ideal}(D)$ is the
encircled energy for an ideal diffraction-limited mirror of equal focal length and
numerical aperture.
35. An apparatus as recited in claim 34, wherein $TSE(D)$ is a monotonically
10 decreasing function of D .
36. A method as recited in claim 32 in which the measurement area is no larger
than 50 microns.
- 15 37. A method for optically inspecting a sample, the method comprising:
generating an optical probe beam;
using a series of optical components to cause a portion of the probe beam to
be reflected by a measurement area on the sample surface and subsequently
transported to a detector, where the series of optical components includes at least one
20 mirror, and where at least 99% of the portion of the probe beam that is reflected by
the measurement area reaches the detector; and
analyzing signals generated by the detector.
38. A method as recited in claim 37, wherein the mirror comprises:
25 a glass substrate; and
a reflective coating.
39. A method as recited in claim 37, wherein the mirror is formed using a glass
master.
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40. A method as recited in claim 37, wherein the mirror is formed by:
diamond turning a substrate to a desired shape; and
polishing the substrate to meet the condition $TSE(D) \leq 2e^{-0.15D}$ where
 $TSE(D) = E_{mirror}(D)/E_{ideal}(D)$ where $E_{mirror}(D)$ is the encircled energy of the
5 mirror measured as a function of the included diameter D and $E_{ideal}(D)$ is the
encircled energy for an ideal diffraction-limited mirror of equal focal length and
numerical aperture.

41. An apparatus as recited in claim 40, wherein $TSE(D)$ is a monotonically
10 decreasing function of D .

42. A method as recited in claim 37, wherein the mirror is formed by:
forming an aluminum substrate to a desired shape; and
super-polishing the substrate to meet the condition $TSE(D) \leq 2e^{-0.15D}$ where
15 $TSE(D) = E_{mirror}(D)/E_{ideal}(D)$ where $E_{mirror}(D)$ is the encircled energy of the
mirror measured as a function of the included diameter D and $E_{ideal}(D)$ is the
encircled energy for an ideal diffraction-limited mirror of equal focal length and
numerical aperture.

20 43. An apparatus as recited in claim 42, wherein $TSE(D)$ is a monotonically
decreasing function of D .

44. A method as recited in claim 37 in which the measurement area is no larger
than 50 microns.

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45. A method for fabricating low-noise optical components for use in optical metrology systems, the method comprising:

creating a substrate that is similar in shape to the component to be produced;

positioning a deformable layer over the substrate; and

5 press forming the deformable layer using a master made from optical glass.

46. A method as recited in claim 45 in which the component is a mirror meeting the condition $TSE(D) \leq 2e^{-0.15D}$ where $TSE(D) = E_{mirror}(D)/E_{ideal}(D)$ where $E_{mirror}(D)$ is the encircled energy of the mirror measured as a function of the included diameter D and

10 $E_{ideal}(D)$ is the encircled energy for an ideal diffraction-limited mirror of equal focal length and numerical aperture.

47. A method as recited in claim 46 in which $TSE(D)$ is a monotonically decreasing function of D .

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